Mixed Stoichiometry Practice

Name _____

Write and/or balance the following equations (remember the diatomic elements and to criss-cross charges for ionic compounds!!!) Use the mole ratios from the balanced equations to solve the following stoichiometry problems. Use units and labels in all conversions, and round your answer to sig figs.

1. Potassium chlorate decomposes into potassium chloride and oxygen gas.

Balanced Equation: $2KClO_3 \rightarrow 2KCl + 3O_2$

2. How many moles of oxygen are produced when 3.0 moles of potassium chlorate decompose completely?

$$3.0 \text{ mol } KClO_3 \left(\frac{3 \text{ mol } O_2}{2 \text{ mol } KClO_3}\right) = 4.5 \text{ mol } O_2$$

3. Butane (C_4H_{10}) undergoes combustion.

Balanced Equation: 2 $C_4H_{10}(l)$ + 13 $O_2(g) \rightarrow$ 8 $CO_2(g)$ + 10 $H_2O(l)$

4. How many grams of CO_2 are produced when 88 g of O_2 are reacted with an excess of butane?

$$88 \text{ g } O_2 \left(\frac{1 \text{ mol } O_2}{32 \text{ g } O_2}\right)\left(\frac{8 \text{ mol } CO_2}{13 \text{ mol } O_2}\right)\left(\frac{44 \text{ g } CO_2}{1 \text{ mol } CO_2}\right) = 74 \text{ g } CO_2$$

5. Water decomposes into hydrogen gas and oxygen gas by electrolysis.

Balanced Equation: $2H_2O \rightarrow 2H_2 + O_2$

6. How many grams of hydrogen will be produced when 6.0 moles of oxygen are produced?

$$6.0 \text{ moles } O_2 \left(\frac{2 \text{ mol } H_2}{1 \text{ mol } O_2}\right)\left(\frac{2 \text{ g } H_2}{1 \text{ mol } H_2}\right) = 24 \text{ g } H_2$$

7. How many grams of water are required to produce 1.5L of hydrogen at STP?

$$1.5 \text{ L } H_2 \left(\frac{1 \text{ mol } H_2}{22.4 \text{ L}}\right)\left(\frac{2 \text{ mol } H_2O}{2 \text{ mol } H_2}\right)\left(\frac{18 \text{ g } H_2O}{1 \text{ mol } H_2O}\right) = 1.2 \text{ g } H_2O$$

8. Cobalt(II) chloride reacts with fluorine in a single replacement reaction to produce cobalt(II) fluoride and chlorine gas.

Balanced Equation: _____ $CoCl_2$ + _____ F_2 → _____ CoF_2 + _____ Cl_2

9. How many grams of fluorine are required to produce 290.8 g of cobalt(II) fluoride?

$$290.8\,g\,CoF_2\left(\frac{1\,mol\,CoF_2}{96.9\,g\,CoF_2}\right)\left(\frac{1\,mol\,F_2}{1\,mol\,CoF_2}\right)\left(\frac{38\,g\,F_2}{1\,mol\,F_2}\right) = 114.0\,g\,F_2$$

10. Balance the following equation.

_____ $SrCl_2(aq)$ + _____ $H_2SO_4(aq)$ → 2 $HCl(aq)$ + _____ $SrSO_4(s)$

11. What is the mass of strontium chloride that reacts with 300.0 g of sulfuric acid?

$$300.0\,g\,H_2SO_4\left(\frac{1\,mol\,H_2SO_4}{108.1\,g\,H_2SO_4}\right)\left(\frac{1\,mol\,SrCl_2}{1\,mol\,H_2SO_4}\right)\left(\frac{158.6\,g\,SrCl_2}{1\,mol\,SrCl_2}\right) = 440.1\,g\,SrCl_2$$

12. Solid iron(III) oxide reacts with hydrogen gas to form iron and water.

Balanced Equation: $Fe_2O_3 + 3H_2 \longrightarrow 2Fe + 3H_2O$

13. How many grams of iron are produced when 450 grams of iron(III) oxide are reacted?

$$450\,g\,Fe_2O_3\left(\frac{1\,mol\,Fe_2O_3}{159.6\,g\,Fe_2O_3}\right)\left(\frac{2\,mol\,Fe}{1\,mol\,Fe_2O_3}\right)\left(\frac{55.8\,g\,Fe}{1\,mole\,Fe}\right) = 310\,g\,Fe$$

14. How many grams of water will be produced when 3.2L of hydrogen gas react completely with iron(III) oxide at STP?

$$3.2\,L\,H_2\left(\frac{1\,mol\,H_2}{22.4\,L\,H_2}\right)\left(\frac{3\,mol\,H_2O}{3\,mol\,H_2}\right)\left(\frac{18\,g\,H_2O}{1\,mol\,H_2O}\right) = 2.6\,g\,H_2O$$

LIMITING REAGENT Practice Problems

1. At high temperatures, sulfur combines with iron to form the brown-black iron (II) sulfide:

$$Fe\ (s) + S\ (l) \rightarrow FeS\ (s)$$

Ratio from Equation: 1 mol Fe : 1 mol S
Ratio from Given: 1 mol Fe : 1.97 mol S
Sulfur is in excess.

In one experiment, 7.62 g of Fe are allowed to react with 8.67 g of S.

a. What is the limiting reagent, and what is the reactant in excess?

$7.62\,g\,Fe\left(\frac{1\,mol}{55.8\,g}\right) = 0.137\,mol\,Fe$ $\quad 8.67\,g\,S\left(\frac{1\,mol}{32\,g}\right) = 0.270\,mol\,S$

$\frac{0.137}{0.137}$ $\quad \frac{0.270}{0.137}$

b. Calculate the mass of FeS formed.

$$7.62\,g\,Fe\left(\frac{1\,mol\,Fe}{55.8\,g}\right)\left(\frac{1\,mol\,FeS}{1\,mol\,Fe}\right)\left(\frac{87.9\,g}{1\,mol\,FeS}\right) = 12.0\,g\,FeS$$

2. Arcylonitrile, C_3H_3N, is the starting material for the production of a kind of synthetic fiber acrylics) and can be made from propylene, C_3H_6, by reaction with nitric oxide, NO, as follows:

$$4\ C_3H_6\ (g) + 6\ NO\ (g) \rightarrow 4\ C_3H_3N\ (s) + 6\ H_2O\ (l) + N_2\ (g)$$

What mass of C_3H_3N can be made when 21.6 g of C3H6 react with 21.6 g of nitric oxide?

NO is limiting

$21.6\,g\,C_3H_6\left(\frac{1\,mol}{42.0\,g}\right) = 0.514\ mol\,C_3H_6$

Ratio from Equation: $4\,C_3H_6 : 6\,NO$, $1\,C_3H_6 : 1.5\,NO$

$21.6\,g\,NO\left(\frac{1\,mol}{30\,g}\right) = 0.720\ mol\,NO$

Ratio from given: $1\,mol\,C_3H_6 : 1.4\,mol\,NO$

$21.6\,g\,NO\left(\frac{1\,mol\,NO}{30\,g\,NO}\right)\left(\frac{4\,mol\,C_3H_6}{6\,mol\,NO}\right)\left(\frac{53\,g}{1\,mol\,C_3H_3N}\right) = 25.4\,g\,C_3H_3N$

3. Formic acid, $HCHO_2$, burns in oxygen to form carbon dioxide and water as follows:

$$HCHO_2\ (aq) + O_2\ (g) \rightarrow 2\ CO_2\ (g) + 2\ H_2O\ (l).$$

If a 3.15-g sample of formic acid was burned in 2.0 L of oxygen, what volume of carbon dioxide would be produced? (Assume the reaction occurs at standard temperature and pressure, STP.)

O_2 is limiting

$3.15\,g\,HCHO_2\left(\frac{1\,mol}{46\,g\,HCHO_2}\right) = 0.685\ mol\,HCHO_2$

from equation: $1\,mol\,HCHO_2 : 1\,mol\,O_2$

$2.0\,L\,O_2\left(\frac{1\,mol}{22.4\,L}\right) = 0.0893\ mol\,O_2$

from given: $7.67\,mol\,HCHO_2 : 1\,mol\,O_2$

$2.0\,L\,O_2\left(\frac{1\,mol\,O_2}{22.4\,L}\right)\left(\frac{2\,mol\,CO_2}{1\,mol\,O_2}\right)\left(\frac{22.4\,L}{1\,mol\,CO_2}\right) = 4.0\,L\,O_2$

4. Zinc metal reacts with hydrochloric acid to produce zinc chloride and hydrogen gas.

a. Balance the following reaction: $Zn\ (s) + 2HCl\ (aq) \rightarrow ZnCl_2\ (aq) + H_2\ (g)$

b. A 3.50-g sample of zinc metal is allowed to react with 2.50 g of hydrochloric acid.

Complete the following table:

Reactants/products	Zn (grams)	HCl (grams)	$ZnCl_2$ (grams)	H_2 (grams)
Before reaction	3.50	2.50	0	0
After reaction	1.26 g (NOT ALL USED)	0	4.67	0.14

MUST BE IN EXCESS

3.

$$2.50\,g\,HCl\left(\frac{1\,mol\,HCl}{36.5\,g}\right)\left(\frac{1\,mol\,ZnCl_2}{2\,mol\,HCl}\right)\left(\frac{136.4\,g}{1\,mol\,ZnCl_2}\right) = 4.67\,g\,ZnCl_2$$

$$2.50\,g\,HCl\left(\frac{1\,mol\,HCl}{36.5\,g}\right)\left(\frac{1\,mol\,H_2}{1\,mol\,HCl}\right)\left(\frac{2\,g}{1\,mol\,H_2}\right) = 0.14\,g\,H_2$$

From given 1 mol MnO_2 : 3.25 mol HCl (limiting)

5. Consider the reaction: $MnO_2 + 4\ HCl \rightarrow MnCl_2 + Cl_2 + 2\ H_2O$
If 0.45 mols of MnO2 can react with 48.2 g of HCl, how many grams of Cl_2 could be produced?

$48.2\text{g HCl}\left(\frac{1\text{mol}}{36.5\text{g}}\right) = 1.3\text{ mol HCl}$ (given) $\quad 0.45\text{ mol } MnO_2$

$48.2\text{g HCl}\left(\frac{1\text{mol HCl}}{36.5\text{g}}\right)\left(\frac{1\text{mol } Cl_2}{4\text{mol HCl}}\right)\left(\frac{71\text{g}}{1\text{mol } Cl_2}\right) = 23.4\text{g } Cl_2$

6. One of the components of the fuel mixture on the Apollo lunar module involved a reaction with hydrazine, N_2H_4, and dinitrogen tetraoxide, N2O4. If the balanced equation for this reaction is

A B
$$2\ N_2H_4\ (l) + N_2O_4\ (g) \rightarrow 3\ N_2\ (g) + 4\ H_2O\ (g),$$

What volume of N_2 gas (measured at STP) would result from the reaction of 1500 kg of hydrazine and 1000 kg of N_2O_4?

$1500\text{ kg A}\left(\frac{1000\text{g}}{1\text{kg}}\right)\left(\frac{1\text{mol A}}{32\text{g}}\right) = 47{,}000\text{ mol A}$ $\quad 1000\text{kg B}\left(\frac{1000\text{g}}{1\text{kg}}\right)\left(\frac{1\text{mol B}}{92\text{g}}\right) = 10{,}000\text{ mol B}$

7. Chlorine gas reacts with silica, SiO_2, and carbon to give silicon tetrachloride and carbon monoxide.
   a. Balance the following equation: $2\ Cl_2\ (g) + SiO_2\ (s) + 2\ C\ (s) \rightarrow SiCl_4\ (l) + 2\ CO\ (g)$

   b. How much CO gas can be produced from 15.0 g of silica?

* No mention of STP
Solve in grams

From given limiting reactant / excess reactant

$\frac{47000\text{ mol A}}{10000\text{ mol B}} = \frac{1\text{mol B}}{4.7\text{mol A}}$

From Equation 1 mol B : 2 mol A

$1000\text{g B}\left(\frac{1000\text{g}}{1\text{kg}}\right)\left(\frac{1\text{mol B}}{92\text{g}}\right)\left(\frac{3\text{mol } N_2}{1\text{mol B}}\right)\left(\frac{22.4\text{L}}{1\text{mol } N_2}\right) = 7\times10^5\text{ L } N_2$

$15.0\text{g } SiO_2\left(\frac{1\text{mol } SiO_2}{60.1\text{g}}\right)\left(\frac{2\text{mol CO}}{1\text{mol } SiO_2}\right)\left(\frac{28\text{g CO}}{1\text{mol CO}}\right) = 14.0\text{g CO}$